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RACUZ DESCRIPTOR APPLICATION METHODOLOGY.(U)  
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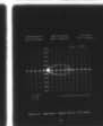
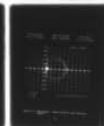
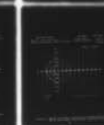
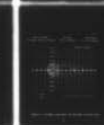
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## RACUZ DESCRIPTOR APPLICATION METHODOLOGY

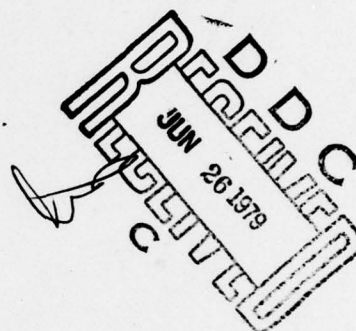
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared to provide range commanders and range planners with a readily applied methodology for addressing land use planning and land use conflict problems arising from the use of various ordnance types on US Air Force tactical training and flight test ranges. The methodology described in this report presents a means for using the products developed under the Range Compatibility Use Zone (RACUZ) Program. This methodology consists of a step-by-step procedure for applying range safety areal descriptors developed under a previous		

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20 Abstract (continued)

contract to a spectrum of range planning, operations, and training problems. The range safety areal descriptors discussed ~~herein~~ are contours about the target, oriented with respect to the direction of weapon delivery, which describe an area expected to contain at least a specified percentage of all initial impact points plus ricochet impact points for weapons delivered against the specified target with specified delivery tactics. The report has been designed to make usable the currently existing areal descriptors when used as reproduced transparent plastic overlays or traced on clear plastic, and to provide a framework for placing at the disposal of the users any future descriptors as they are developed and any modifications to the methodology.

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## SUMMARY

This report has been prepared to provide range commanders and range planners with a readily applied methodology for addressing land use planning and land use conflict problems arising from the use of various ordnance types on the U.S. Air Force flight test and tactical training ranges. The methodology described in this report presents a means for using the products developed under the Range Compatible Use Zone Program.

The methodology consists of a step-by-step procedure for applying the range safety areal descriptors to a spectrum of range planning, operations, and training problems. The range safety areal descriptors discussed herein are contours about the target, oriented with respect to the direction of weapon delivery, which describe an area expected to contain at least a specified percentage of all initial impact points plus ricochet impact points for weapons delivered against the specified target with specified delivery tactics.

The report has been designed to make usable the currently existing areal descriptors and to provide a framework for placing at the disposal of the users any future descriptors as they are developed and any extensions or modifications to the methodology.

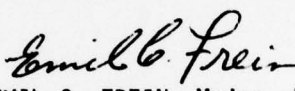
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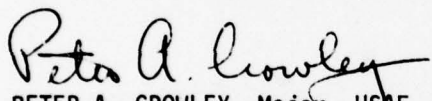
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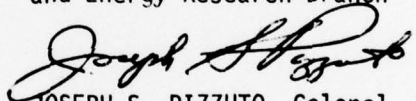
This report has been reviewed by the Information Officer (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public including foreign nations.

This technical report has been reviewed and is approved for publication.

  
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## SECTION I

### INTRODUCTION

#### 1. RACUZ BACKGROUND

A continuing long term responsibility of the U.S. Air Force is the operation and maintenance of the USAF flight test and training ranges. Meeting this responsibility requires a continuing planning and evaluation activity to assure that the long term mission requirements can be met and to assure an adequate margin of safety for the people and property located on or near the ranges. Historically, the land area associated with these ranges has been sufficient to provide the required assurances. However, as the weapons and delivery tactics have become more sophisticated, and as the population has continued to encroach on the range boundaries, the range planning and area adequacy evaluation activities have become increasingly more difficult. To aid these planning and evaluation activities, the Air Force established a Range Compatible Use Zone (RACUZ) program.

A key objective of the RACUZ program is to develop a quantitative, relatively simple and direct method for describing the land area required to contain a given percentage of ordnance expended during test and training activities. This methodology is to fit within the overall planning framework, is to be applicable to both current and planned ranges, and is to address the entire spectrum of current and planned weapons. The methodology is to provide the range planner with a mechanism to identify possible incompatible land usages on current ranges and to avoid, during the planning process, the creation of land use conflicts on future ranges. The methodology is also to provide the various range commanders with a mechanism for assessing the land area adequacy, from a

safety point-of-view, of a given range for a specified mission.

The product developed to meet this key objective of the RACUZ project consists of: (1) a set of munition impact point containment contours (areal descriptors), and (2) a set of rules detailing the proper application of the areal descriptors to range planning and range operation problems. The set of areal descriptors for unguided ordnance and the techniques for their generation were developed as part of a previous study performed under Contract No. F08635-74-C-0029.

The purpose of this report is to place the presently developed descriptors and the rules for their proper application at the disposal of range planners and range commanders. The report also provides a framework for placing at the disposal of these users any new descriptors as they are developed.

## 2. REPORT ORGANIZATION

The contents of this report are designed to provide the user with the necessary background understanding and a step-by-step process for applying areal descriptors to a variety of range operations and range planning problems. Although the contents of each Section deal explicitly with the areal descriptors which have been developed for unguided munitions delivered using modern delivery tactics, it is anticipated that the contents will apply with equal validity to descriptors developed for advanced guided weapons.

This report is divided into three sections plus an appendix. The three sections describe (1) the RACUZ descriptor methodology terms, interpretation, and spectrum of applications, (2) the application process, and (3) the limitations on descriptor application process. The appendix contains a brief discussion for each of the range safety areal descriptors, and plotted graphs scaled for use with range maps.

## SECTION II

### RACUZ DESCRIPTOR METHODOLOGY

#### 1. RACUZ DESCRIPTOR METHODOLOGY DEFINITIONS

##### a. Definitions

The following definitions are basic to understanding and properly applying the RACUZ Descriptor Methodology.

RACUZ Descriptor Methodology - The method developed to provide the USAF range commanders and range planners with a rapid, easily applied, and direct method for circumscribing the area which would be subjected to a potential hazard as a result of munitions testing or training activities on air-to-ground ranges.

Areal Descriptor - An areal descriptor is a closed contour about a target location, oriented with respect to the intended weapon delivery direction, which defines an area expected to contain at least a specified percentage of the impact points and subsequent ricochet impacts, if any, of munitions delivered against the target with specified tactics.

Composite Areal Descriptor - A composite areal descriptor or composite descriptor is the single descriptor which defines the area expected to contain at least a specified percentage of the initial impact points plus ricochet impact points for a combination of weapons or targets or tactics.

Tactics Mix - The tactics mix is the set of aircraft altitude, velocity, and dive angle combinations at weapon launch (or release or fire) used in the derivation of a given area's descriptor.

Target/Terrain Type - Target/terrain type refers to the structural composition of either the target or terrain. Hard targets are steel or concrete structures; soft targets are

wood or earthen structures. Hard terrain contains large rocks or concrete or is a hard packed surface; soft terrain is a sandy or cleared plowed surface.

Outlier Impact - An outlier impact is an impact of the weapon that occurs at an unusually large miss distance from the intended target. (A large miss distance generally means more than 2000 feet.)

Land Use Conflict - Land use conflict refers to those actual, planned, or potential uses of an area which are not compatible, for reasons of safety, with their use as an ordnance testing or training area.

Conflict Areas - A conflict area is an area either on or off the range for which a land use conflict has been identified.

b. Discussion of Definitions

The areal requirement for safety for weapon testing or training exercises is described in terms of a potential hazard area. This hazard area may be determined through use of the areal descriptors for each weapon/tactic/target combination of interest. The hazard associated with ordnance testing and training exercises is assumed to arise from impacts of the weapon. As a consequence, the areal descriptors have been designed to describe an area expected to contain specified percentages of the impact points. Various percentages of containment are defined to permit the user to select those containment criteria most applicable to his particular problem.

Two types of weapon impacts are considered in the areal descriptor definition: the initial impacts of the weapon and subsequent ricochet impacts.

The three primary factors which determine the size of an areal descriptor are the delivery tactic, the weapon type, and the target/terrain composition. These parameters are used to specify a given areal descriptor and are discussed in greater detail in Section III.

## 2. ADDRESSABLE/NON-ADDRESSABLE PROBLEM CATEGORIES

The RACUZ Descriptor Methodology is not designed to solve all range planning and range operation problems. Instead, it is designed to furnish an initial approach to identifying or avoiding potential land use conflicts from a safety point-of-view. It is important for the user to understand when a problem can be addressed using the methodology and when a problem resolution will require a more detailed analysis.

### a. Addressable Problem Categories

The categories of problems which can be addressed using the RACUZ Descriptor Methodology all involve either the identification of or the avoidance of land use conflicts. The methodology is not designed, except in the most simple cases, to resolve the conflicts. Specifically, in support of range operation efforts, the technique for identifying hazardous areas can be used to:

- (1) assess the adequacy of range land area to support or accept future planned missions,
- (2) identify weapon/delivery tactic combinations which are permissible on a given range area,
- (3) identify, for a given range and specific missions, the existence or non-existence of land use conflicts.

Example: Land use conflicts which are readily identified are the location of manned facilities within a hazard area and the identification of a hazard area that extends beyond the range boundary.

In support of range planning efforts, the technique can be used to avoid the creation of land use conflicts by

- (1) identifying the suitable locations for range facilities such as instrumentation sites, access roads, and targets,
- (2) specifying for the planned range the permissible weapon/delivery tactic combinations, and

(3) If given the desired mission, specify the land area required to support the mission from a safety point-of-view.

In support of both range operations and range planning efforts, the RACUZ Descriptor Methodology may be applied either to the total mission or to particular subelements of the mission.

b. Non-Addressable Problem Categories

The RACUZ Descriptor Methodology is not designed to resolve all range planning and operation problems regarding land usage. Specifically, when a land use conflict is identified, the formulation and selection of alternatives may depend upon numerous factors in addition to safety and, hence, will require a more detailed analysis. This analysis comes during the planning process. Further, the RACUZ methodology is based upon the application of specific areal descriptors. When a problem is formulated for which there exists no areal descriptors, then obviously the methodology is not applicable.

A particular aspect that must be addressed in resolving land use conflicts is the risk to personnel, property, and environs. Areal descriptors cannot be used to determine risk levels. They can, however, be used to identify problem areas for which a detailed analysis should be considered to quantify the magnitude of the risk.

## SECTION III

### RACUZ DESCRIPTOR APPLICATION METHODOLOGY

#### 1. STEP-BY-STEP APPLICATION PROCESS

The step-by-step procedure for applying the RACUZ areal descriptors to a range planning or range operation problem is shown in Figure 1, pg. 8. Figure 1 is broken into four sections corresponding to the four top-level steps used in determining the areal adequacy of a range to support a given mission. These top-level steps are:

- Step 1 - Statement of the problem, data collection, and selection of appropriate descriptors.
- Step 2 - Application of the descriptors to define the potential hazard area for the spectrum of weapons, tactics, and targets which comprise the mission definition.
- Step 3 - Identification of any land use conflicts associated with the actual or planned activities.
- Step 4 - The determination that the land area is adequate for safety or the determination to seek the alternative solutions and the specification of appropriate decision actions and supportive analyses.

Each substep of the application process shown in Figure 1 is numbered to furnish an identifying key. The identified substeps are discussed in subsection 2 of this section. The steps are identified again in an illustrative example given in subsection 3 of this section. Use of the referenced subsections will insure that the user is continually aware of any restrictions, limitations, or assumptions relevant to his particular problem.

Step 1 Problem Definition and Descriptor Selection

Step 2 Hazard Area Determination

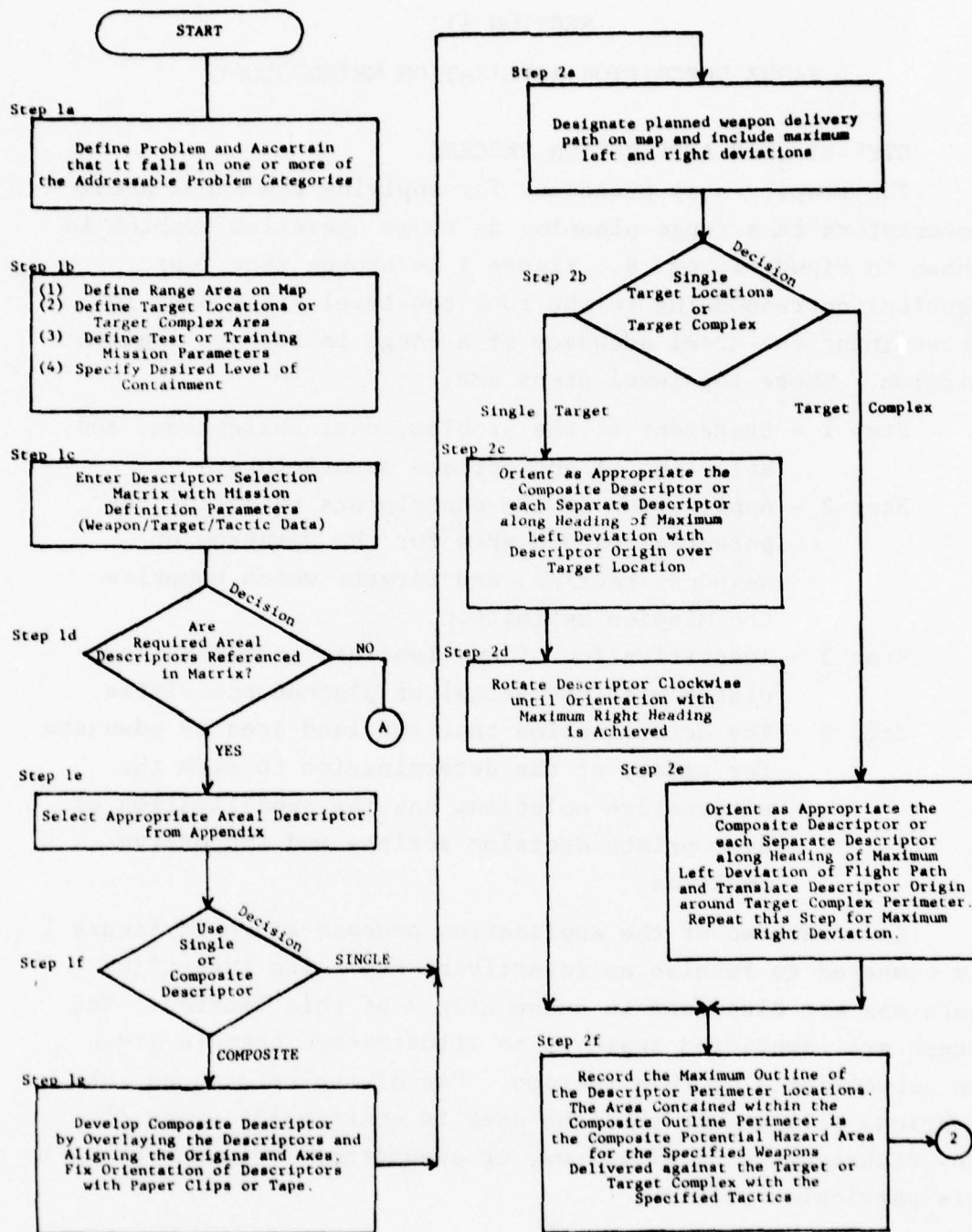


Figure 1 Step-by-Step Procedure for Applying the RACUZ area Descriptors

Step 3 Land Use Conflict Identification

Step 4 Alternatives and Decision Actions

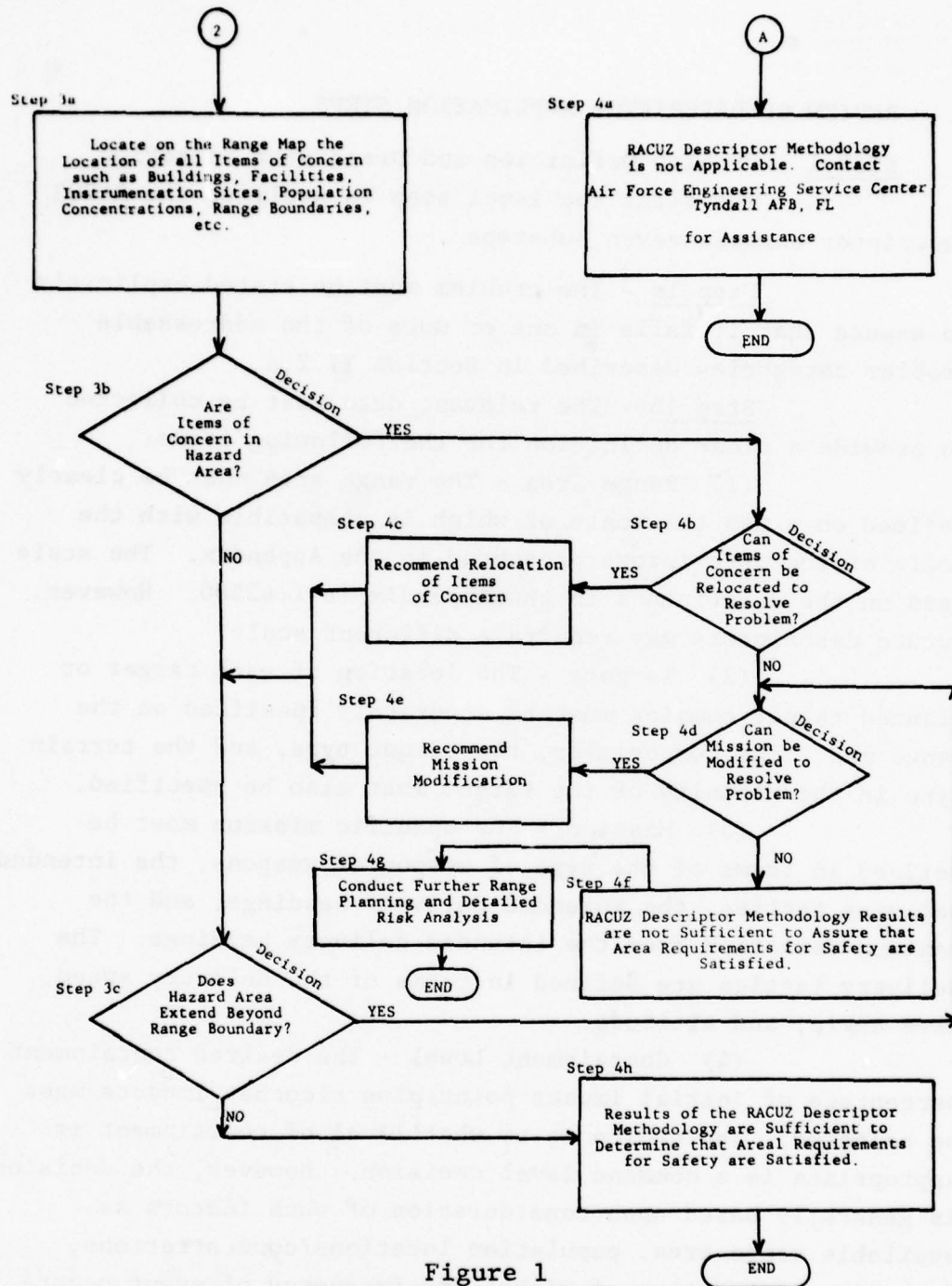


Figure 1  
Step-By-Step Procedure  
for Applying the RACUZ Area Descriptors (concluded)

## 2. REVIEW OF DESCRIPTOR APPLICATION STEPS

### STEP 1 - Problem Definition and Descriptor Selection

The first top-level step in applying the RACUZ descriptor entails seven substeps.

Step 1a - The problem must be stated explicitly to assure that it falls in one or more of the addressable problem categories described in Section II.2.a.

Step 1b - The relevant data must be collected to provide a clear definition for the following items:

(1) Range area - The range area must be clearly defined on a map the scale of which is compatible with the scale of the descriptors presented in the Appendix. The scale used on the descriptors in the Appendix is 1:62500. However, future descriptors may require a different scale.

(2) Targets - The location of each target or planned target complex must be accurately specified on the range map. The composition, the target type, and the terrain type in the vicinity of the target must also be specified.

(3) Mission - The specific mission must be defined in terms of the type of weapon or weapons, the intended delivery tactics, the intended delivery headings, and the maximum deviation from the intended delivery headings. The delivery tactics are defined in terms of the delivery speed, dive angle, and altitude.

(4) Containment Level - The desired containment percentage of initial impact point plus ricochet impacts must be selected. The choice as to what level of containment is appropriate is a command level decision. However, the decision is generally based upon consideration of such factors as available range area, population locations/concentrations, lethality, perception of risks, and frequency of event occurrence. The actual quantification of these factors requires

a detailed risk analysis. However, if a high level of concern exists for any of these factors, a high level of containment should be specified. Containment level specification should be commensurate with level of concern. Descriptors are provided for 99.99, 99.9, and 99.5 percent containment levels, however, the various containment levels must not be mixed, interpolated, or extrapolated.

Step 1c - The mission, target, and containment level data collected in Step 1b are used in conjunction with Table A-1, pg. 26, to identify the descriptors required for the solution of the given problem.

Step 1d - If descriptors for the defined mission, target, and containment level are not referenced in the descriptor selection matrix, then the methodology is not applicable and the user should proceed to Step 4a.

Step 1e - If all of the required descriptors are referenced in the descriptor selection matrix, the required descriptors should be traced on clear plastic for usage as overlays on the actual range maps.

Step 1f - In some instances, it is appropriate to overlay the resulting descriptor transparencies one on the other with axes and origins aligned. This is done to simplify their application and is not a required step. Combining descriptors is appropriate and useful when different weapons are to be used against the same target and delivered within similar envelopes. Further, if one is evaluating an explicit mission involving multiple weapons and tactics, the composite descriptor provides a quick look capability. If manipulation of any of the mission parameters is anticipated in order to arrive at a safety solution, the descriptors should be applied one at a time.

Step 1g - If it is determined that descriptor composition is desirable, the composite descriptor is formed by overlaying the descriptors one on the other with origins and axes aligned. This orientation may be fixed using tape, paper clips, or other appropriate method. The composite outline at the specified containment level is the composite descriptor, and should be traced on a separate sheet of clear plastic for use in later steps.

STEP 2 - Hazard Area Determination

The second top-level step is to determine the hazard area for the defined problem. This step has six substeps.

Step 2a - Relative to each of the intended targets or target complexes, designate the maximum left and right deviations from the nominal delivery heading. These lines will be used to properly orient the areal descriptors for application to the particular mission.

Step 2b - A slightly different treatment method is used if the targets are to be located within a target complex area as opposed to a specific location. Choose the appropriate branch of the logic sequence.

Step 2c - For a specific target location, the composite descriptor or each separate descriptor is placed on the range map with the origin over the target and the axis oriented along the direction of maximum right heading deviation.

Step 2d - Rotate the descriptor or descriptors about the target in a clockwise direction until the descriptor axis is aligned with the direction of maximum left heading deviation. Proceed to step 2f to determine the actual hazard area.

Step 2e - If a target complex is being considered, the composite descriptor or each separate descriptor, as

appropriate, is applied to the perimeter of the target complex instead of to individual target locations. The descriptor axis is oriented along the direction of maximum right deviation and the descriptor origin is translated around the target complex perimeter. This step is repeated with the axis oriented in the direction of maximum left deviation.

Step 2f - Record the maximum outline described by the descriptor boundaries as they were applied in steps 2c, 2d, and 2e. The area contained within the composite outline is the potential hazard area for the defined problem, that is for the specified weapons, tactics, targets, and delivery envelopes.

### STEP 3 - Land Use Conflict Identification

The third top-level step is to identify possible land use conflicts. The criteria used for this determination are the presence of manned or high valued facilities within the hazard area or the overlapping of a range boundary by the hazard area. This step consists of three substeps.

Step 3a - Part of the problem definition step entailed the identification of all population concentrations, buildings, facilities, and manned instrumentation sites. This step requires the location of all these items of concern on the range map. Some of the locations may be for consideration purposes only, for example, alternative building sites.

Step 3b - If any of the items of concern are located in the hazard area they constitute a land use conflict and a decision must be made as to how the conflict can be resolved. This is addressed in Step 4b.

Step 3c - If the hazard area extends beyond the range boundary, that portion of the hazard area outside of the range constitutes a potential land use conflict. This conflict is addressed in Step 4d.

#### STEP 4 - Alternatives and Decision Actions

The fourth top-level step is to make the determination as to whether or not the range area is sufficient to assure safety. If the determination can be made within the RACUZ descriptor framework, the steps are identified. If the determination cannot be made within the RACUZ descriptor framework, the appropriate recommendations and additional analysis areas are identified.

Step 4a - If in Step 1d it was determined that the descriptors referenced in the descriptor selection matrix were not the descriptors required for the defined problem, then the user should contact the Air Force Engineering Service Center (AFESC) at Tyndall Air Force Base, Florida, for assistance. AFESC has the methodologies for developing descriptors for specific user requirements.

Step 4b - If the items of concern that comprise the land use conflict can be relocated outside of the hazard area, then the land use conflict can be resolved.

Step 4c - If relocation of the items of concern can resolve the land use conflict, the relocation should be recommended.

Step 4d - If relocation is not possible, then modification of the mission parameters should be considered. This could entail restricting delivery headings, target locations, delivery tactics or even eliminating use of particular weapons from the defined range mission.

Step 4e - If mission modification can resolve the land use conflict, then the appropriate mission modification should be recommended for consideration in the use conflict resolution decisions.

Step 4f - If neither Step 4c or Step 4e are feasible, then the land use conflicts identified in Steps 3b and 3c cannot be resolved within the framework provided by the RACUZ Descriptor Methodology.

Step 4g - Once the resolution of the identified land use conflicts has been determined to be outside the scope of the RACUZ Descriptor Methodology, other analysis and planning efforts must be used. These efforts require the formulation of the decision alternatives and the evaluation of those alternatives. One of the evaluation techniques available is risk level assessment. AFESC can provide the user with analytical assistance in performing detailed risk level analysis.

Step 4h - If Steps 3b and 3c do not identify any land use conflict areas, then the area requirements for safety are satisfied.

### 3. ILLUSTRATIVE EXAMPLE

The following range planning example problem is given to illustrate the various steps used in the RACUZ Descriptor Methodology.

#### Step 1. Example Problem Definition

Assume the following hypothetical situation:

It is desired to locate a new set of targets for both bombs and rockets within a currently existing target complex area located on an existing range. Soft targets will be emplaced for bomb drops and hard targets for rocket shots. The suitability of the target complex area is to be examined for accepting the new target emplacements. It is also desired to determine a suitable location on the range for a new manned radar facility to be used in conjunction with the exercises. Because of the population encroachment problems around this range, the Commander desires to determine if the range has sufficient area to assure a high level of impact point containment. As a consequence of his concern, it is specified that planning efforts will assure containment levels of 99.99 percent.

The primary delivery tactics are to be low altitude (300 to 1500 ft.), high speed (450 to 520 knots), and low dive angle (0 to 20 degrees) deliveries. The delivery flight azimuths are restricted because of physical constraints (i.e., mountains) to plus or minus 15 degrees of the nominal delivery direction (due east).

Determination of methodology applicability is made by determining whether or not range safety areal descriptors exist for the specified mission. In particular, descriptors are required for:

- (1) GP Bombs  
Low Altitude  
High Speed  
Low Dive Angle
- (2) 2.75-Inch Rockets  
Low Altitude  
Low Dive Angle  
Hard Structure Targets

When the descriptor selection matrix (Table A-1) is entered with these parameters, the two descriptors shown in Figures A-1 and A-7 are identified. The required descriptors are available and hence the method is applicable.

Since the same target complex area is to be examined for both targets and since the delivery envelopes are to be similar, combining the descriptors for both weapon categories into a single composite descriptor will simplify the mechanics of hazard area determination. The composite descriptor is shown in Figure 2.

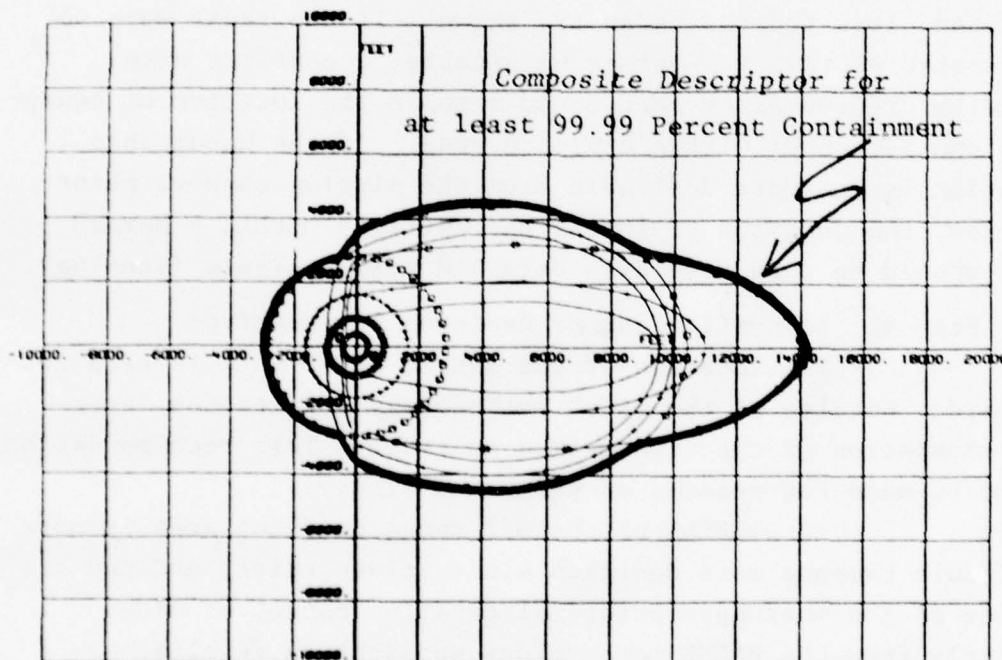


Figure 2. Composite Descriptor for Example Case

#### Step 2. Hazard Area Determination

The descriptor for 99.99 percent containment is now applied to the perimeter of the target complex. It is applied to the perimeter since the targets may be located anywhere within the complex. The application of the descriptor reflects both the maximum left and right deviations from the intended delivery heading. The result of this process is shown in Figure 3.

#### Step 3. Conflict Area Identification

In Figure 3, it is seen that a portion of the hazard area overlaps the range boundary. The area off range is a conflict area since it has potential uses not compatible with ordnance impacts. Additionally, in Figure 3 the two proposed sites for the radar are shown. If the radar were to be located at the site marked unsuitable, a conflict area would be created since this would require the location of equipment and personnel within a hazard area. If the unsuitable location is the most desirable from the mission support point-of-view, the decision to locate the facility within a hazard area should be supported by a detailed risk analysis (step 4g).

#### Step 4. Identification of Decision Alternatives

The location of the manned radar site is straightforward. Results of the RACUZ methodology application favor recommendation of the site marked suitable. This recommendation would be made for reasons of personnel safety.

Resolution of the off range conflict area is more difficult because more decision alternatives exist, and the choice of the most appropriate alternative cannot be made strictly from the RACUZ methodology application results.

Among the alternatives that should be considered are:

(1) Restrict the target locations to sites in the target complex behind the indicated dotted line.

(2) Restrict the delivery heading deviation to the left to within 5 degrees of the nominal.

(3) Acquire the off range land or otherwise acquire control of the area during the test and training exercises.

(4) Accept the risk of not controlling the area. Rationale for choosing between these choices and possibly others requires analysis beyond the scope of the RACUZ Descriptor Methodology and recommendations should be made to perform the additional studies.

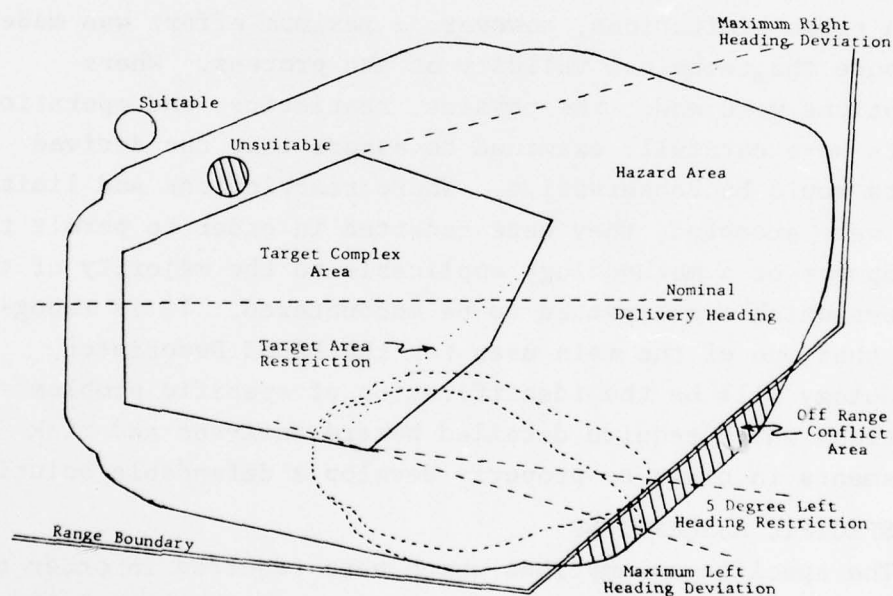


Figure 3. Hazard Area Determination and Conflict Area Identification

SECTION IV  
ASSUMPTIONS AND LIMITATIONS ASSOCIATED  
WITH THE RACUZ DESCRIPTOR USAGE

1. REQUIREMENT FOR ASSUMPTIONS

The RACUZ descriptor methodology is designed to be a relatively simple and easily applied technique for addressing problems requiring the identification of the land requirements for safe operation over air-to-ground ordnance delivery ranges. In order to develop this simple methodology, many assumptions were made and the acceptance of some limitations was necessary. Within these limitations, however, a maximum effort was made to assure the technical validity of the process. Where assumptions were made, the physics, statistics, and operational aspects were carefully examined to assure that the derived results would be conservative. Where restrictions and limitations were accepted, they were accepted in order to permit the development of a methodology applicable to the majority of the problems which are expected to be encountered. It is recognized that one of the main uses for the RACUZ Descriptor Methodology will be the identification of specific problem situations which require detailed hazard analyses and risk assessments in order to properly develop a defensible solution.

2. SPECIFIC ASSUMPTIONS

The specific assumptions which were required in order to develop the RACUZ methodology can be grouped into the following categories: tactics and mixes, target types, terrain types, physical parameters, and data base adequacy.

Some of the assumptions have much more influence on the validity of the methodology than do the others, but in all instances, the user of this methodology should be aware of the underlying assumptions in order to avoid unwarranted or inappropriate applications.

a. Tactics and Mixes

Numerous tactics and combinations of tactics are used in the delivery of unguided air-to-ground ordnance. The choice of which tactic is employed has a great influence on the distribution of initial impact points, whether or not ricochet occurs, and, if so, how far the ricochet travels. In the derivation of the RACUZ areal descriptors, only those tactics defined in Table A-1, pg. 26, were used. The statistical distributions used for the tactics definition parameters and the logic used for mixing them were developed in a previous study prepared under Contract No. F08635-74-C-0029.

b. Target and Terrain Types

The target composition and the terrain surrounding the target have a profound effect on weapon ricochet. Hard terrain and hard structured targets cause a higher frequency of ricochets and a greater angular dispersion of ricochets. In addition, ricochets from hard surfaces travel further than do ricochets from soft targets or soft terrain. In the derivation of the RACUZ descriptors, it was assumed that hard structured targets would not be used for tactical dive bombing training exercises. Therefore no descriptors were developed for bombs against hard targets. Further, it was assumed that hard structured targets would be used for rocket and gunnery training. Therefore, descriptors for both hard and soft targets were developed for those munitions.

The terrain surrounding the intended target influences the nature of the weapon ricochet in several ways. First, the irregularities of the terrain surface influences the direction of weapon ricochet. Second, hard surfaces, like hard targets, cause more frequent and longer flight ricochets than do soft surfaces. Additionally, when soft terrains are assumed, impacts will be absorbed. However, every time a round is absorbed, the probability that a succeeding round will strike

an imbedded round increases. A ricochet off an imbedded round is similar to a ricochet off a hard structure target. In the derivation of the RACUZ descriptors, it was assumed that this event would occur less than ten percent of the time.

c. Physical Parameters

Quantitative values were required for a large number of physical parameters. These values included estimates for ballistic coefficients, critical ricochet angles, weapon dimensions and weights.

d. Data Base Adequacy

Many sources which contained historical impact point data for unguided weapon deliveries were surveyed during the RACUZ data base development. The data sources reviewed were limited to fairly recent data. Sources reviewed included the Rand Corporation Southeast Asia Combat Data Archives and their Air-to-Ground Weapons Delivery files; Nellis AFB and the Armament Development and Test Center (ADTC) libraries; and the SANDIA Corporation files on tactical nuclear weapon deliveries. The ADTC survey included data from Eglin AFB tests, data available from or generated through Joint Munitions Effectiveness Manual activities, and data for large caliber weapons tested at Ballistics Research Laboratory.

Of the bomb impact point data sources surveyed, most of the data sets were deemed unsuitable for inclusion in this study since the extreme miss distances were either not scored because they were out of the field of view or they were placed into a single category as being greater than some preassigned distance. The data sources which contained both the extreme miss data and normal delivery data have been compiled into a single comprehensive data base to support the RACUZ study. The data on level tactical nuclear deliveries have been incorporated into the RACUZ data base to provide sample points for high speed, low level delivery tactics. The RACUZ data

base is maintained at AFESC/RDVW, Tyndall AFB, Florida.

The size of the RACUZ data base is sufficiently large to make statements which are statistically valid at the 95 percent confidence level regarding the distribution of initial impact points. However, similar statements cannot be made regarding the ricochet impact points since the ricochet contribution to the overall distribution was derived using simulation techniques rather than data sampling techniques.

### 3. LIMITATIONS

There are a few explicit limitations of the RACUZ methodology of which the user must be aware in order to avoid improper or invalid applications.

#### a. Resolution of Land Use Conflicts

The RACUZ Descriptor Methodology can identify those land use conflicts which arise as a result of the areal requirements for safety. The descriptors are useful in identifying possible alternatives which can be pursued to resolve the conflicts. However, the descriptors are not applicable to the process required to evaluate the level of risk within either the hazard area as a whole or in a conflict area.

#### b. Applicable Tactics

The RACUZ areal descriptors were derived using a specified set of tactics defined in terms of weapon delivery parameters. During the descriptor development process, assumptions were made which necessitated the restriction of descriptor validity to only those described tactics in the data base. These tactics are described in Table A-1 in the Appendix, and application of the descriptors to other possible tactics is not valid.

#### c. Containment Level

The descriptors for unguided air-to-ground ordnance

were derived for three specified levels of containment for user convenience. The descriptors must not be extrapolated to estimate containment contours for higher levels of containment. The descriptors as presented contain insufficient data to permit interpolation and extrapolation with any meaningful level of confidence.

All of the individual descriptors used for the construction of a composite descriptor should use the same specified level of containment.

APPENDIX  
RANGE SAFETY AREAL DESCRIPTORS

A.1 AREAL DESCRIPTORS FOR UNGUIDED AIR-TO-GROUND WEAPONS

This appendix provides a set of range safety areal descriptors for the class of inert unguided air-to-ground weapons delivered using modern tactical delivery practices. The descriptors are scaled for compatibility with standard range maps having a scale of 1:62500. As new descriptors are developed, other scales may be appropriate. The guide for selecting the descriptors required for a specific problem is provided in Table A-1, pg. 26. Caution should be exercised should copies be made of the descriptors since many copying machines produce copies with a slight geometrical magnification.

TABLE A-1 DESCRIPTOR SELECTION MATRIX

Event Type	Delivery Tactics/Conditions at Release or Fire			Target/Terrain	Descriptor No
	Speed **	Altitude *	Dive Angle		
<u>Dive Bombing</u> GP Bombs	High Speed (400 to 570 Knots)	Low Altitude (300 to 1500 feet)	Low Dive Angle (0 to 20 degrees)	Soft	A-1
	Low Speed (300 to 400 Knots)	Low Altitude (300 to 1500 feet)	Low Dive Angle (0 to 20 degrees)	Soft	A-2
	(300 to 520 Knots)	High Altitude (1500 to 12000 feet)	High Dive Angle (20 to 60 degrees)	Soft	A-3
	300 to 450 Knots	Below 1000 feet	Level	Soft	A-3
<u>Rockets</u> 2.75-Inch	300 to 570 Knots	High Altitude (2000 to 10000 feet)	High Dive Angle (20 to 60 degrees)	Soft	A-4
	300 to 570 Knots	High Altitude (2000 to 10000 feet)	High Dive Angle (20 to 60 degrees)	Hard	A-5
	300 to 570 Knots	Low Altitude (1500 to 2000 feet)	Low Dive Angle (10 to 20 degrees)	Soft	A-6
	300 to 570 Knots	Low Altitude (1500 to 2000 feet)	Low Dive Angle (10 to 20 degrees)	Hard	A-7
<u>Strafing</u> 20 mm	420 to 570 Knots	Open Fire Range 1800 to 3000 feet	10 to 20 degrees	Soft	A-8
	420 to 570 Knots	1800 to 3000 feet	10 to 20 degrees	Hard	A-9
	420 to 570 Knots	1800 to 3000 feet	10 to 20 degrees	Soft	A-10
	420 to 570 Knots	1800 to 3000 feet	10 to 20 degrees	Hard	A-11

\* All altitudes are above ground level (AGL)

\*\* All airspeeds are knots true airspeed (KTAS)

## A.2 AREAL DESCRIPTORS FOR DIVE BOMBING

The range safety areal descriptors for dive bombing are shown in Figures A-1 through A-3. The scale for these descriptors is 1:62500. The descriptors are for containment levels of 99.5 percent, 99.9 percent, and 99.99 percent at the 95 percent statistical confidence level in the underlying initial impact data. These data are meant to be interpreted in the following way: the 99.9 percent containment descriptor has 0.95 probability of containing at least 99.9 percent of all initial impacts. A conservatively simulated ricochet distance for weapons delivered under the captioned tactics has been statistically added.

2500109

CE 541 Y  
10 10

Delivery Speed                      Altitude                      Dive Angle  
GP Bombs: 400 to 570 Knots    300 to 1500 feet            0 to 20 degrees

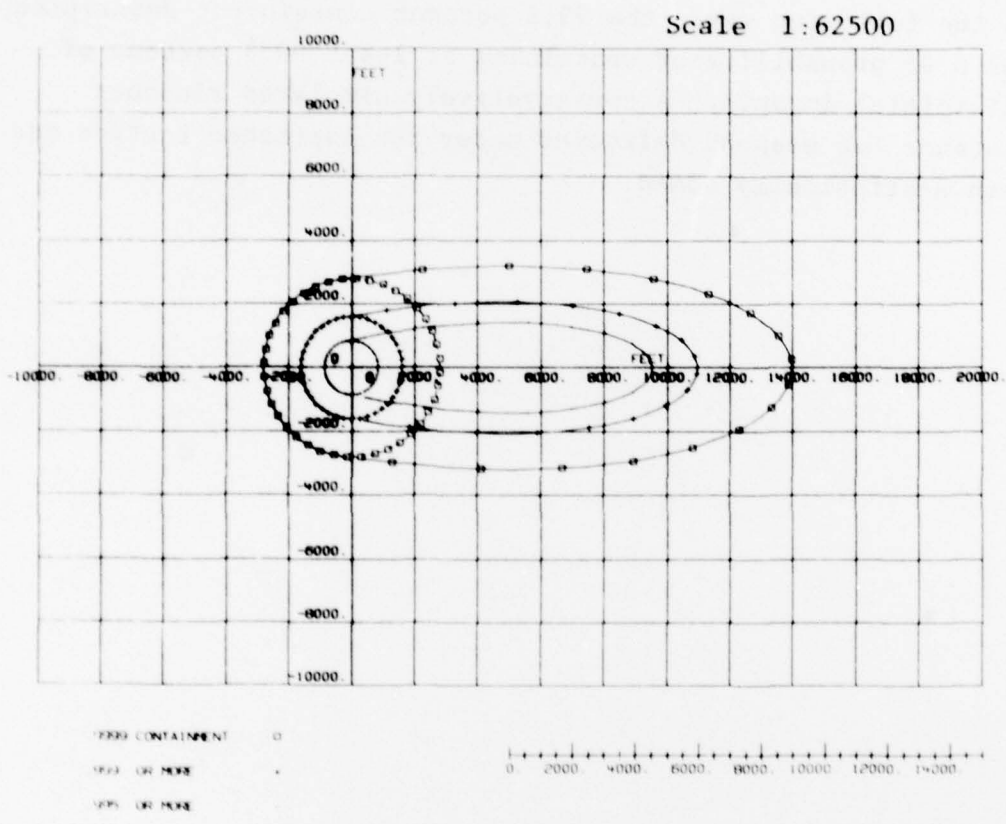


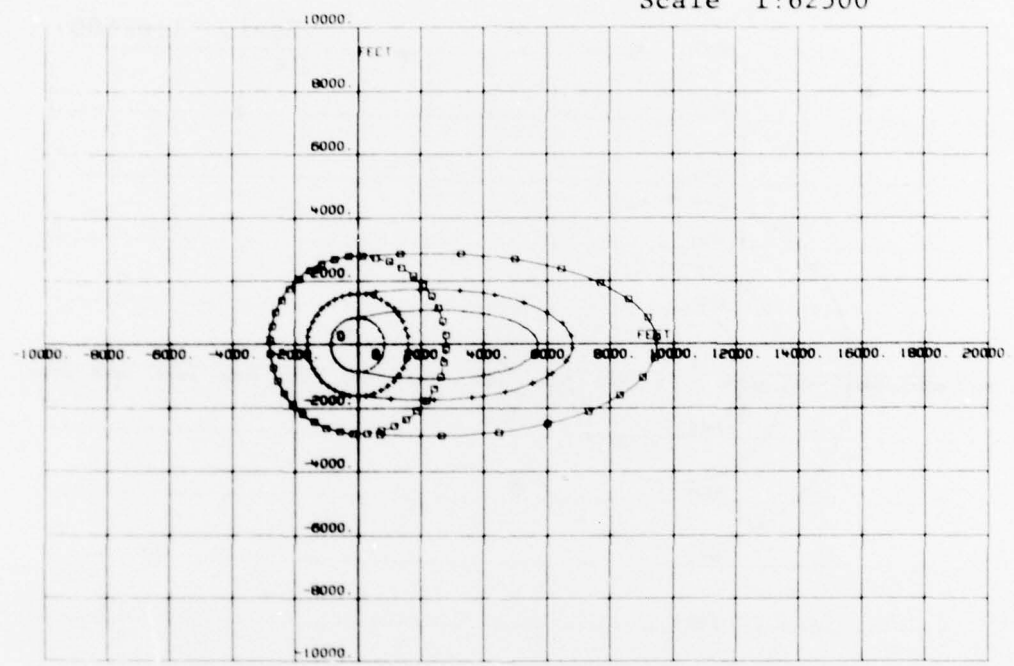
Figure A-1 GP Bombs: High Speed, Low Altitude, Low Dive Angle

TABLE 7

CEX-500  
11 11

Delivery Speed	Altitude	Dive Angle
GP Bombs: 300 to 400 Knots	300 to 1500 feet	0 to 20 Degrees

Scale 1:62500



WATER CONTAINMENT 0  
 100% OR MORE  
 100% OR MORE

0 2000 4000 6000 8000 10000 12000 14000

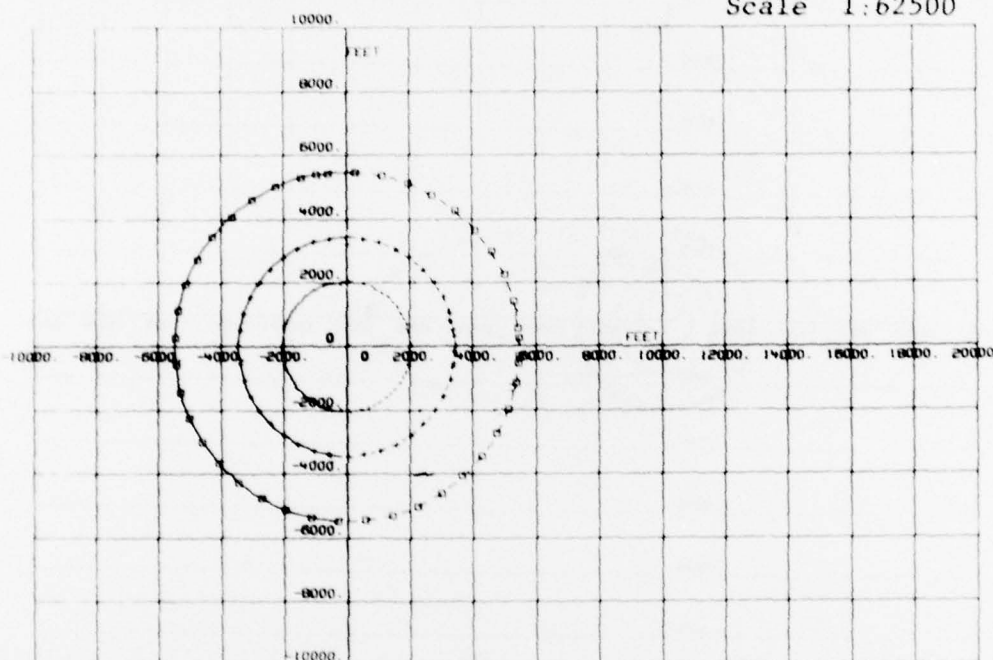
Figure A-2 GP Bombs: Low Speed, Low Altitude, Low Dive Angle

SECRET

SECRET

Delivery Speeds	Altitude	Dive Angle
MK-106: 300 to 650 Knots	below 1000 ft	Level
BDU-33 and GP Bombs: 300 to 520 Knots	1500 to 12000 ft	20 to 60 degrees

Scale 1:62500



GRAB CONTAINMENT

GRAB ON FIRE

GRAB ON FIRE

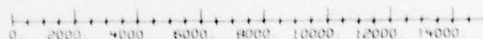


Figure A-3 MK-106: All Speeds, Low Altitude, Straight and Level;  
BDU-33 and GP Bombs: High Altitude, High Dive Angle

### A.3 AREAL DESCRIPTORS FOR 2.75-INCH ROCKETS

Dive angle is the primary parameter which affects the frequency of ricochet for 2.75-inch rockets. Since the distribution of initial impacts is relatively insensitive to delivery velocity, only two sets of range safety areal descriptors have been developed. One set is for high dive angle deliveries and the other is for low dive angle deliveries. In both categories, areal descriptors are provided for both hard and soft targets and for 99.5 percent, 99.9 percent, and 99.99 percent containment. No delivery velocity breakout is required. These areal descriptors are shown in Figures A-4 through A-7.

25/01/79

CE 5441 Y 5 5

Delivery Speed	Altitude	Dive Angle
300 to 570 Knots	2000 to 10000 feet	20 to 60 degrees

Scale 1:62500

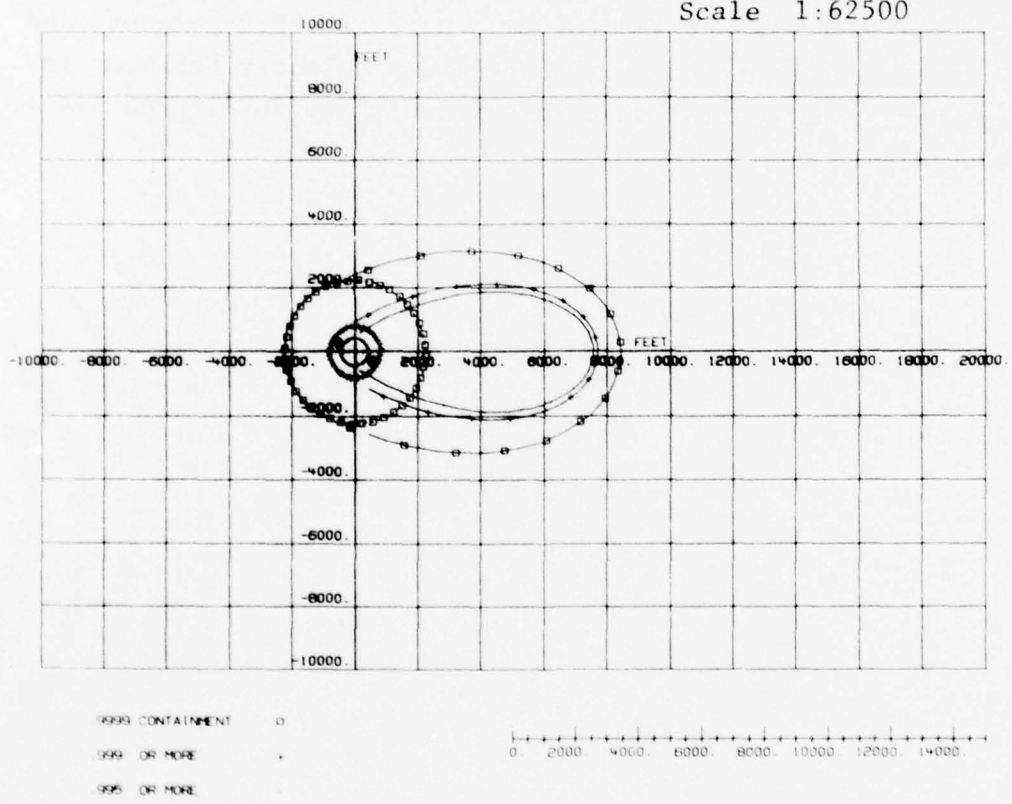


Figure A-4 2.75-Inch Rockets: High Altitude, High Dive Angle, Soft Targets

25/01/79

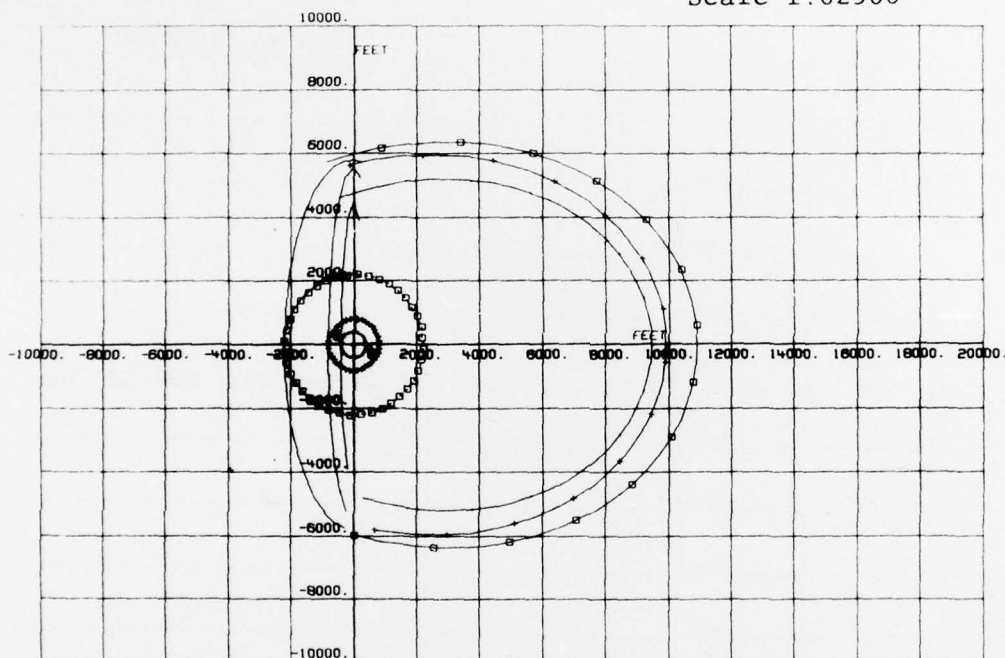
CE 5417  
B B

Delivery Speed  
300 to 570 Knots

Altitude  
2000 to 10000 feet

Dive Angle  
20 to 60 degrees

Scale 1:62500



9999 CONTAINMENT □  
991 OR MORE +  
995 OR MORE .

0 2000 4000 6000 8000 10000 12000 14000

Figure A-5 2.75-Inch Rockets: High Altitude, High Dive Angle, Hard Structure Targets

250-11-79

CE 341.1  
6 6

Delivery Speed  
300 to 570 Knots

Altitude  
1500 to 2000 feet

Dive Angle  
10 to 20 degrees

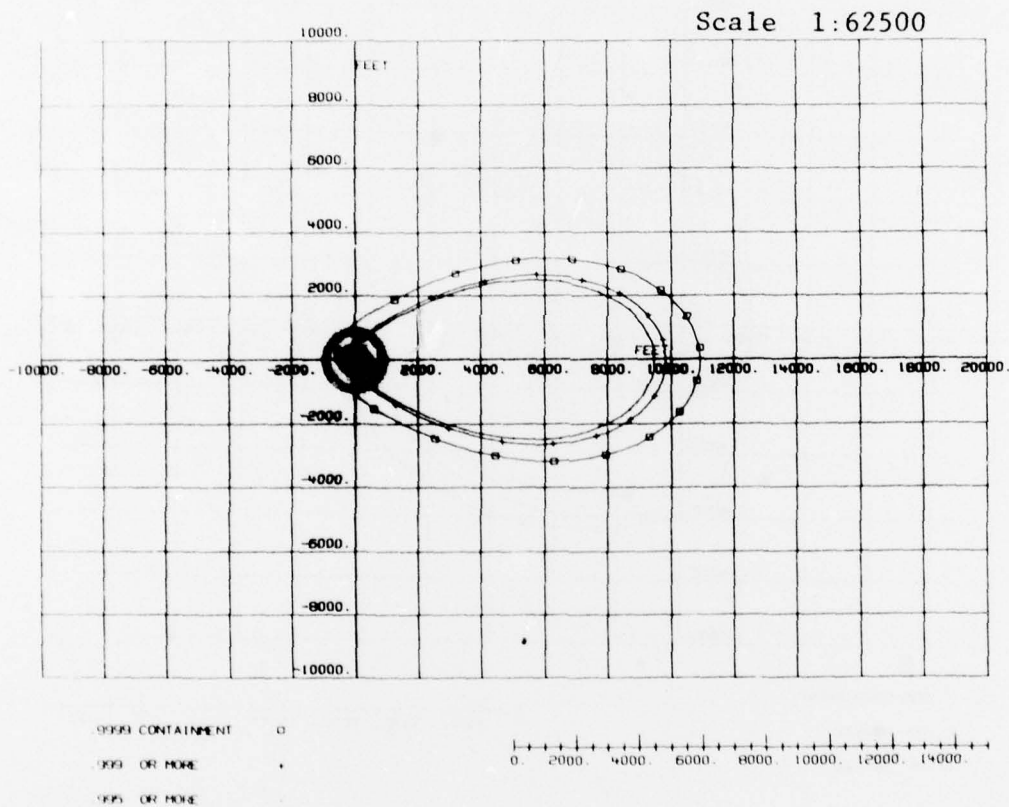


Figure A-6 2.75-Inch Rockets: Low Altitude, Low Dive Angle,  
Soft Targets

SECRET

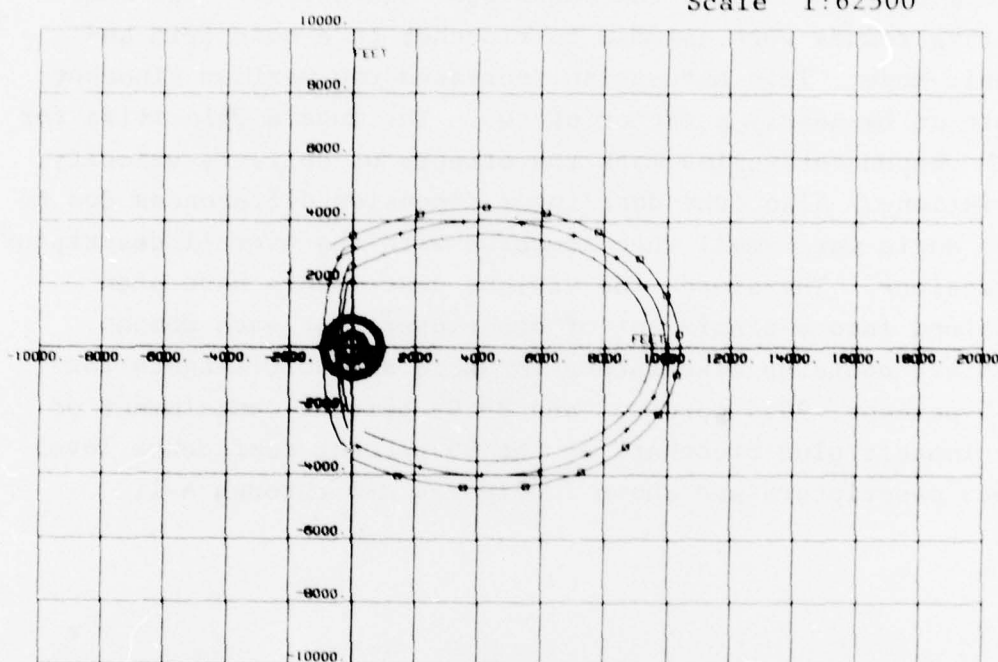
SECRET

Delivery Speed  
300 to 570 Knots

Altitude  
1500 to 2000 feet

Dive Angle  
10 to 20 degrees

Scale 1:62500



ORBIT CONTAINMENT 0  
ORBIT OR MORE 1  
ORBIT OR MORE 2

0 2000 4000 6000 8000 10000 12000 14000

Figure A-7 2.75-Inch Rockets: Low Altitude, Low Dive Angle, Hard Structure Targets

#### A.4 AREAL DESCRIPTORS FOR GUNNERY

Descriptors were developed for both 20-mm and 30-mm gunnery. The initial impact point data for 30-mm gunnery were extrapolated from 20-mm due to an inadequate 30-mm data base. For both weapon categories, ricochet is the primary determining factor for the descriptor dimensions. All ricocheting rounds were assumed to ricochet in a near trim and stable mode. This assumption increased the maximum ricochet distance by nearly a factor of two. The muzzle velocities for both weapon categories mask the effects of delivery velocity variations. Also, the descriptor dimension differences due to dive angle were small when compared with the overall descriptor dimensions. Therefore, the various descriptors have been combined into a single set of descriptors for each weapon. Each set contains descriptors for hard and soft targets for 99.5 percent, 99.9 percent, and 99.99 percent containment of all impacts plus ricochets at the 95 percent confidence level. These descriptors are shown in Figures A-8 through A-11.

29-01-79

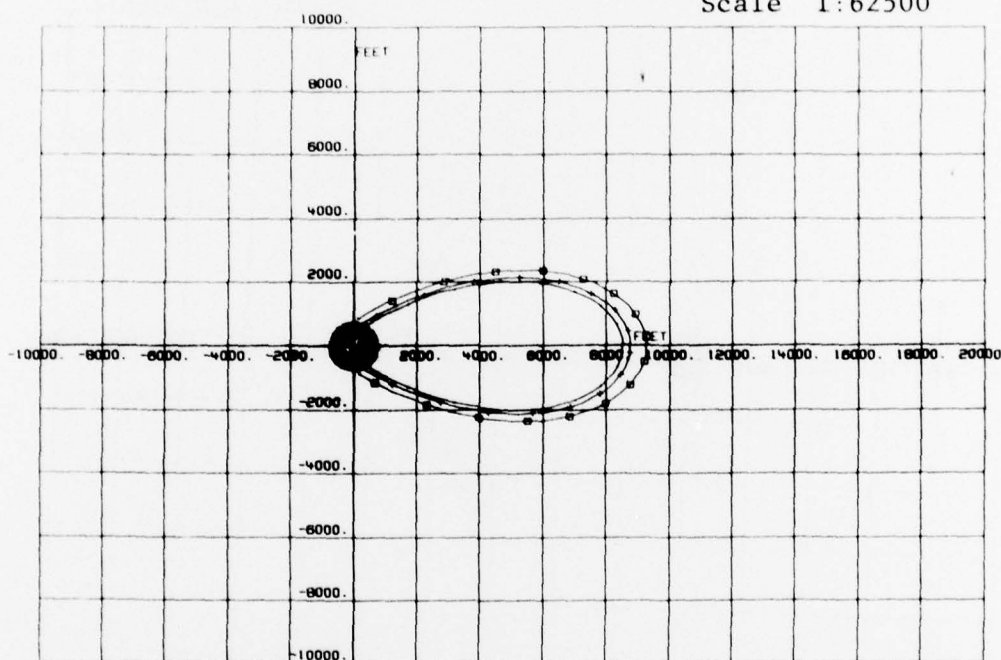
CE 5041

Delivery Speed  
420 to 570 knots

Open Fire Range  
1800 to 3000 feet

Dive Angle  
10 to 20 degrees

Scale 1:62500



.9999 CONTAINMENT 0  
.999 OR MORE 1  
.995 OR MORE 2

0 2000 4000 6000 8000 10000 12000 14000

Figure A-8 20mm Rounds: General Tactics, Soft Targets

7901179

CE 8514

Delivery Speed  
420 to 570 Knots

Open Fire Range  
1800 to 3000 feet

Dive Angle  
10 to 20 degrees

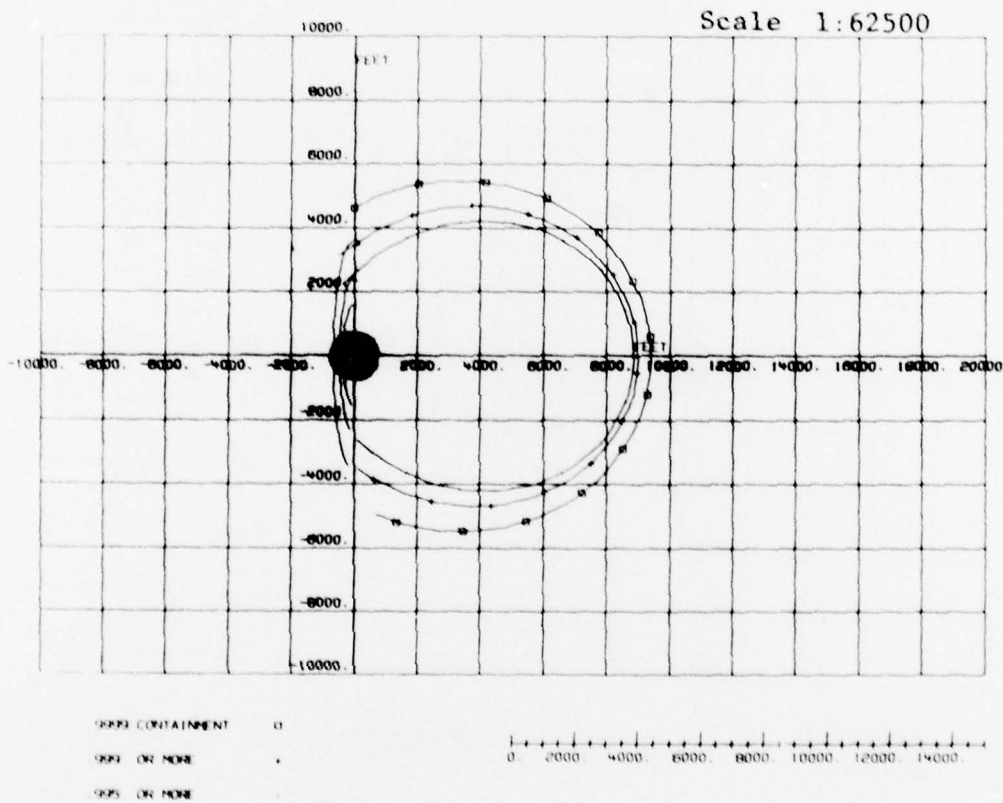


Figure A-9 20mm Rounds: General Tactics, Hard Structure Targets

Delivery Speed  
420 to 570 Knots

Open Fire Range  
1800 to 3000 feet

Dive Angle  
10 to 20 degrees

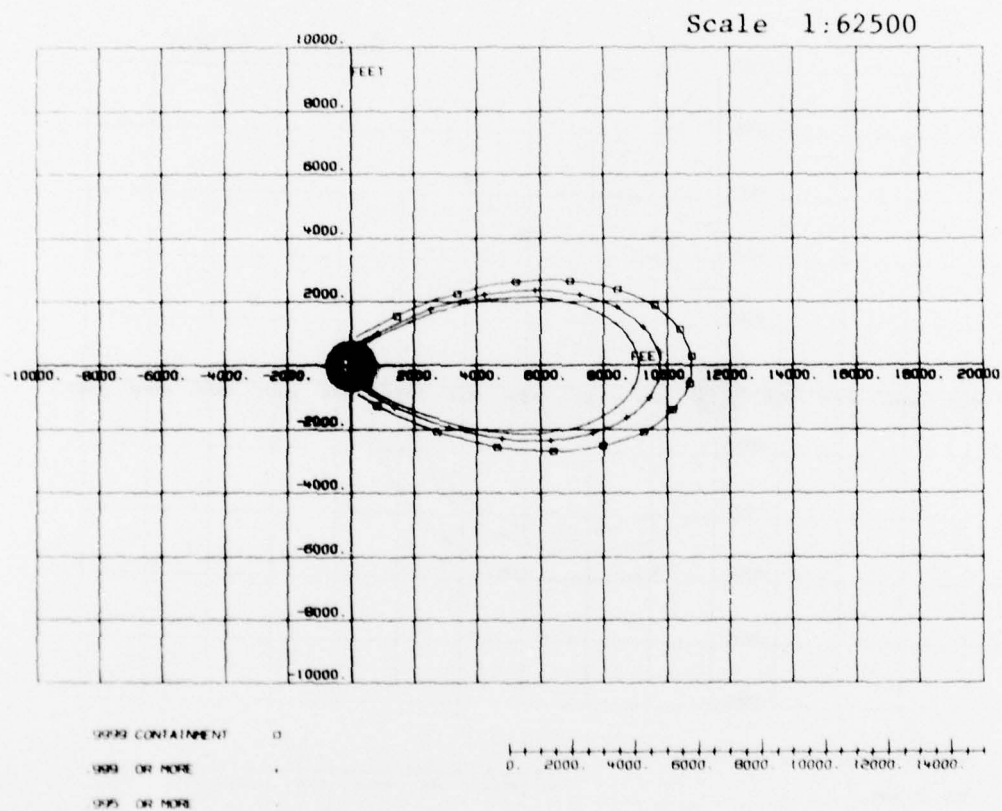


Figure A-10 30mm Rounds: General Tactics, Soft Targets

2901179

CE 5014

Delivery Speed  
420 to 570 Knots

Open Fire Range  
1800 to 3000 feet

Dive Angle  
10 to 20 degrees

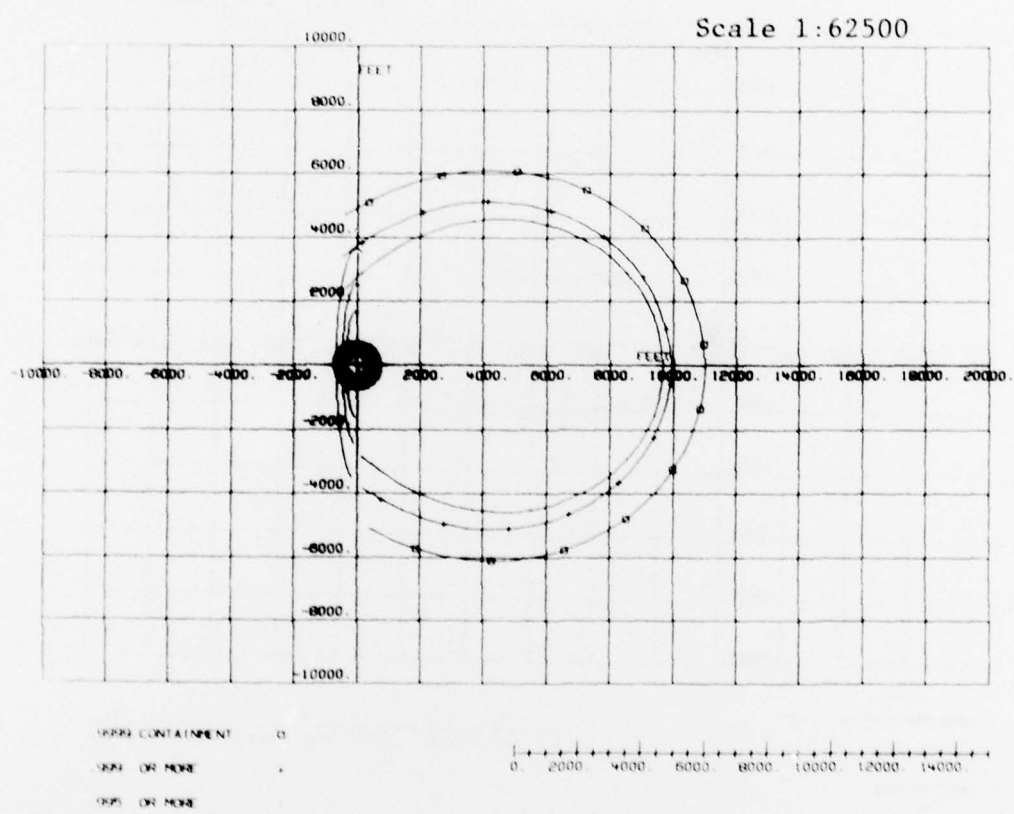


Figure A-11 30mm Rounds: General Tactics, Hard Structure Targets

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HQ AFISC	2
HQ AUL/LSE 71-249	1
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AFATL/CC	1
AFFTC/CC	1
ADTC/CC	1
USAFRCE/WR	1
USAFRCE/CR	1
USAFRCE/ER	1
NCEL, Code 25111	1
NWC	1
HQ TAC/DOR	2
HQ USAFE/DOO	1
HQ PACAF/DOO	1
HQ AAC/DOO	1
US Army/CERL	1
HQ AFRES/DOOT	1
NGB/XOS	1
ADTC/SESR	6
AFIT/DEM	1
HQ AFESC/RDV	6